Research Note 84-76

AD-A144 152

ANALYSIS OF REWARD FUNCTIONS IN LEARNING:
UNCONSCIOUS INFORMATION PROCESSING:
NONCOGNITIVE DETERMINANTS OF RESPONSE STRENGTH

Melvin H. Marx
University of Missouri, Columbia

David W. Bessemer, Contracting Officer's Representative

Submitted by
Robert M. Sasmor, Director
BASIC RESEARCH

U. S. Army

Research Institute for the Behavioral and Social Sciences

May 1984

Approved for public release; distribution unlimited.

This report, as submitted by the contractor, has been cleared for release to Defense Technical Information Center (DTIC) to comply with regulatory requirements. It has been given no primary distribution other than to DTIC and will be available only through DTIC or other reference services such as the National Technical Information Service (NTIS). The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

84 08 09 091

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Research Note 84-76	2. GOVT ACCESSION NO. AD-A144152	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ANALYSIS OF REWARD FUNCTIONS IN LEARNING: UNCONSCIOUS INFORMATION PROCESSING: NONCOGNITIVE DETERMINANTS OF RESPONSE STRENGTH		5. TYPE OF REPORT & PERIOD COVERED Final Report Sept. 1978 - Sept. 15, 1982 6. PERFORMING ORG. REPORT NUMBER --
7. AUTHOR(s) Melvin H. Marx		8. CONTRACT OR GRANT NUMBER(s) MDA 903-78-G-0008
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Missouri Columbia, MO 65211		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q161102B74F
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Research Institute Field Unit--Fort Knox, Steele Hall Fort Knox, KY 40121		12. REPORT DATE May 1984 13. NUMBER OF PAGES 18
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue Alexandria, VA 22333		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE --

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

--

18. SUPPLEMENTARY NOTES

Contract monitored by David W. Bessemer.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Reinforcement, analysis of
Subliminal stimulation
Unconscious information processing
Error analysis
Response strength
Noncognitive determinants of response strength
Reward

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Our overall objective was to investigate the role of non-cognitive determinants of response strength. The more specific objective was to determine whether rewarded responses are differentially processed ("tagged"), as revealed by analysis of their subliminal processing. The major focus of the research was to ascertain the reality of claims recently made for subliminal or "preconscious" processing. --For example, that graphemic and semantic processing persists in spite of the subjects' inability to identify pattern-masked visual cues. In spite of timing limitations associated (Continued)

20. (Continued)

with the 60 Hz refreshing of our CRT display, we found consistent suprachance selection of test alternatives that were graphemic, phonemic, and semantic associates of the target words, in the absence of any ability to identify the target words themselves. Control stimulations (blanks) produced chance performance. It was concluded that these results (1) offer support for the reality of subliminal or unconscious information processing, (2) indicate the feasibility of subliminal testing of the hypothesized differential processing of rewarded responses, and (3) suggest the potential utility of adapting subliminal stimulation techniques as training procedures designed to enhance perceptual skills under severely degraded stimulus conditions, such as the detection of hidden targets in military operations. Related research on several other aspects of the reinforcement problem was also completed and reports were published. These are summarized and some implications for training suggested.

FOREWORD

The Basic Research Office of the Army Research Institute for the Behavioral and Social Sciences is responsible for research programs on fundamental concepts, theories, and methods needed to support applied research and development for Army problems. Research on conditions affecting the processes of learning and retention contribute directly to development and improvement of training technologies applied to military skills.

This report presents the results of a number of experiments that examine relatively unconscious or automatic influences on learning. The findings point to limitations in cognitive views of learning and performance, suggesting a broader view including noncognitive as well as cognitive determinants. The research is suggestive of applications to perceptual skills, such as visual target detection and to the treatment of errors in training.

ANALYSIS OF REWARD FUNCTIONS IN LEARNING

EXECUTIVE SUMMARY

Requirement:

Basic research on concepts, theories, and methods related to processes of learning and performance is needed in developing new and improved approaches to solve applied military training problems. This research examined noncognitive factors influencing acquisition and retention of response strength. Such factors compliment cognitive determinants in helping to account for instances of incorrect performance when cognitive processes are imperfect.

Procedure:

The research focused first on claims made for subliminal or "preconscious" processing, i.e., that aspects of form or meaning of visually presented information can affect subsequent behavior without some awareness of the existence or nature of the original information. A series of experiments were performed using a visual masking procedure. A target word was presented briefly on a CRT, followed after a brief interval by a masking pattern (a row of asterisks) preventing conscious identification of the target. Participants were then asked to select one word from a set of four that either (1) looked like, (2) sounded like, or (3) was associated with the target. Blank trials, with no target word presented, were used as controls. The experiments manipulated the time interval between onset of the target and mask, as well as several other variables.

A number of other experiments were completed (1) comparing effects of performance and observation on transfer in recall and discrimination tasks, (2) examining factors affecting persistence of errors, (3) and the relationship between word recall and anagram problem solution.

Findings:

In the subliminal processing experiments, selection of the alternatives related to the target word graphically, phonetically, or semantically was found consistently at probabilities exceeding chance. Control trials (blanks) produced chance performance. These results (1) support the reality of subliminal or unconscious information processing, (2) suggest that similar methods are feasible to examine differences in processing between rewarded and nonrewarded responses, and (3) suggest that subliminal stimulation techniques may prove useful in relation to perceptual skill training for severely degraded visual conditions, such as target detection.

The remaining experiments point to instances were cognitive processing may interfere with the effectiveness of learning and retention. The results emphasize the importance of a broad view in which both cognitive and noncognitive factors are recognized as influencing performance.

Utilization of Findings:

The series of experiments reported here are useful sources of ideas and methods for researchers in human factors and training. Specifically, the report suggests techniques for (1) the investigation of visual information processing and skill training in target detection, and (2) methods for examining the role of reward and the treatment of error responses in military task training.

CONTENTS

LIST OF FIGURES

I. UNCONSCIOUS PROCESSING OF INFORMATION

Problem

The experimental hypothesis that led to these experiments is that in the absence of any conscious recognition, or correlated verbal representations of such recognition, reward can have response-tagging or response-strengthening effects. In much the same way as many researchers (e.g., Wickens, 1970) now hypothesize that perception of some cue instantaneously and unconsciously effects multiple encodings (e.g., four-legged animal, beast of burden, mammal, etc. for a horse cue), so the role of reward can be conceptualized as somehow infusing "reinforced" responses with greater associative strength.

Before we could attempt to apply the subliminal stimulation technique to the reinforcement problem, we felt that we needed to be sure that the techniques, still controversial within the field of perception, could be depended upon to produce the kind of results that had been claimed for them in other laboratories. Accordingly our first task was to replicate some of the recent research.

The role of preconscious information processing has received a considerable amount of experimental attention within recent years (Dixon, 1981). The reports of Marcel (1978, 1980), in particular, have stimulated a number of attempts at replication and extension of his provocative results. For example, he has claimed (Marcel, 1978) that semantic processing is somehow "prior" to graphemic processing, because his subjects were able to select semantically related test alternatives at shorter stimulus-onset asynchronies (SOAs) than they selected graphemically related alternatives following subliminal presentation of a target word followed by a mask. Apart from this specific comparison, both graphemic and semantic test alternatives were selected at well beyond chance levels by subjects who were apparently not aware of the existence, let alone the identity, of the masked target words.

Published reports bearing on Marcel's research have produced distinctly mixed results. Nolan and Caramazza (1982), for example, have failed to replicate his claim that semantic information can be processed and influence test behavior in the absence of identification, or even detection, of the target words. Although Fowler, Welford, Slade, and Tassinary (1981) also did not replicate this aspect of Marcel's work, they did replicate his (1980) finding of subliminal associative priming. They report that they are "confident that the priming effects of words masked well below the recognition threshold are quite real" (p. 361). However, this priming research along with Marcel's has been recently criticized on grounds of inadequate threshold determination by Merikle (1982), who concludes that the evidence does not contradict Eriksen's (1960) proposition that "verbal reports are as sensitive an indicator of perception as any response that has been studied" (p. 301).

Our study was designed primarily to replicate Marcel's finding of extra-chance selection of test alternatives related to the target word, following presentation of target word and mask at SOAs not permitting recognition of the target word, as measured by the subject's identification efforts. The conclusion by Fowler et al. (1981) that they failed to replicate Marcel's results was based on the control data they obtained in a "nonexperiment" (no target words actually presented), although better-than-chance results had been obtained earlier in several experiments described as variants of Marcel's original experiment. Our research used different kinds of control (blank) manipulations as well as different threshold-determination procedure and additional controls in the target words and the foils (e.g., control of the "envelope" -- the pattern of ascending and descending lower-case letters, in words of the same length and initial letter).

Like Fowler, et al. (1981), we used phonemic as well as graphemic and semantic test alternatives. A secondary purpose of the study was to permit comparisons of semantic with both graphemic and phonemic selections so as to provide data bearing on Marcel's (1978) surprising suggestion of semantic priority in processing.

The two phases of this research will be described separately.

Phase I

General Method

In these six experiments a total of 61 introductory psychology students attempted to select previously (briefly) presented target words from four alternatives. Three tests were run after each target word. Graphemic associates (e.g., bail after presentation of bait), phonemic associates (e.g., late after bait), and semantic associates (e.g., fish after bait) were used. Subjects were asked to select the word that (1) looked like, (2) sounded like, or (3) was associated with, the target. A single such associate and three (unrelated) foils constituted each test. In one experiment the target word itself was included as the fourth alternative. In another experiment only blanks (no target words) were presented as a control.

Presentation of each target word was followed by a visual mask (a row of asterisks) so as to prevent conscious identification of the target. In these experiments a number of different stimulus-presentation times were used, as a means of varying the SOA between target and mask, thereby manipulating the amount of information processing permitted. Although the nominal values of 10 through 70 msec stimulus presentation had been used in the experiments, after investigation of the raster-scan CRT timing problem these values were recalibrated, and all data collected at 10 and 20 msec values were discarded.

Results

In Experiment 1, all three types of test showed a regular increment in percentage correct (that is, graphemic, phonemic, or semantic alternative selected when shown with three foils). Target words were shown first at an estimated 88.9 msec, then at 58.0, 47.7, 37.4, and 27.1 msec intervals. The results are shown in Figure 1. ANOVA indicated highly reliable increments for all three tests, with graphemic scores reliably higher than semantic. All three were clearly above the chance baseline (25); graphemic and phonemic curves started above 50%, semantic above 40% correct. The slopes of all the curves were virtually identical, with no suggestion of an interaction. Finally, there was no gender difference (but only 4 female and 4 male subjects participated) and no gender difference occurred in any subsequent experiments in which equal numbers of male and female subjects permitted comparisons.

A subsequent experiment manipulated the order in which the tests were given, with no difference in results, except that the graphemic curve now clearly surpassed the phonemic. These data are shown in Figure 2. In another subsequent experiment the three types of test alternatives were pitted directly against each other (with a fourth unrelated alternative as a foil) rather than only against foils as in the earlier experiments. Here the graphemic superiority was most clearly demonstrated, as shown in Figure 3.

We concluded from these experiments that both graphemic and phonemic processing was superior to semantic, as reflected in higher selection scores, thus not confirming Marcel's report of prior semantic processing, although all three types gave suprachance results. Because of the methodological questions about these experiments, however, we ran some additional experiments.

Phase II

A great deal of effort was expended in developing the methodology for the subliminal stimulation research. After completing six experiments utilizing our computerized apparatus we found that timing limitations in our CRTs severely restricted our research designs. The difficulty was associated with the raster-scan feature of the CRT; periodic refreshing of the visual display is accomplished on a line frequency of 60Hz, so that the minimum timing interval that can be effectively used with this type of device is no less than 16.7 msec.

In an extended methodological investigation of this problem (reported by Broyles, Prill, Marx, Salthouse, and Spencer, in press), the timing accuracy of stimulus presentations was examined by empirical measurement of the number of refresh cycles occurring over a range of "nominal" intervals (10, 20, 30, 40, 50, 60, and 70 msec). The results indicated that the minimum nominal time interval that can be used with this kind of computer-CRT arrangement is 20 msec, and that additions of 30 msec be used to insure

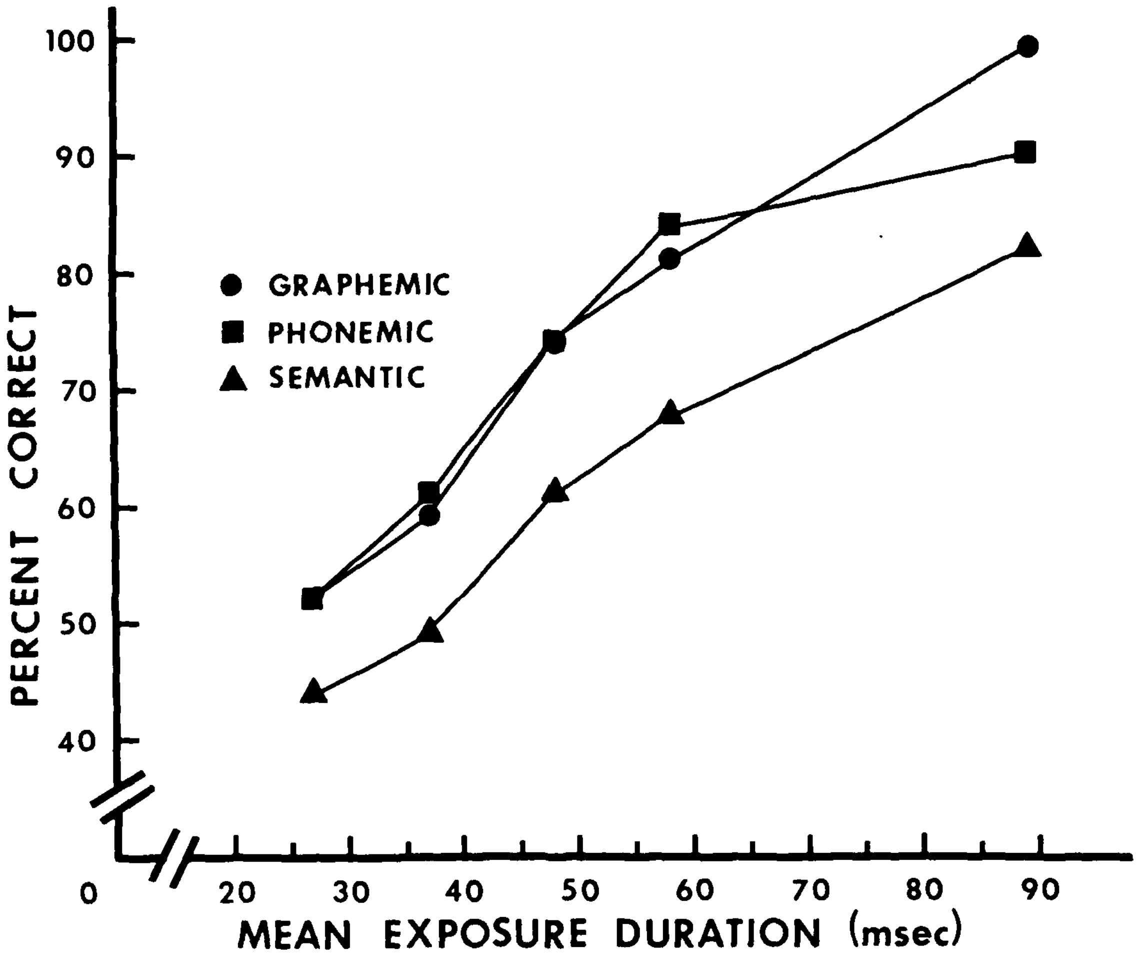

Figure 1. Mean numbers of correct responses to the three types of questions.

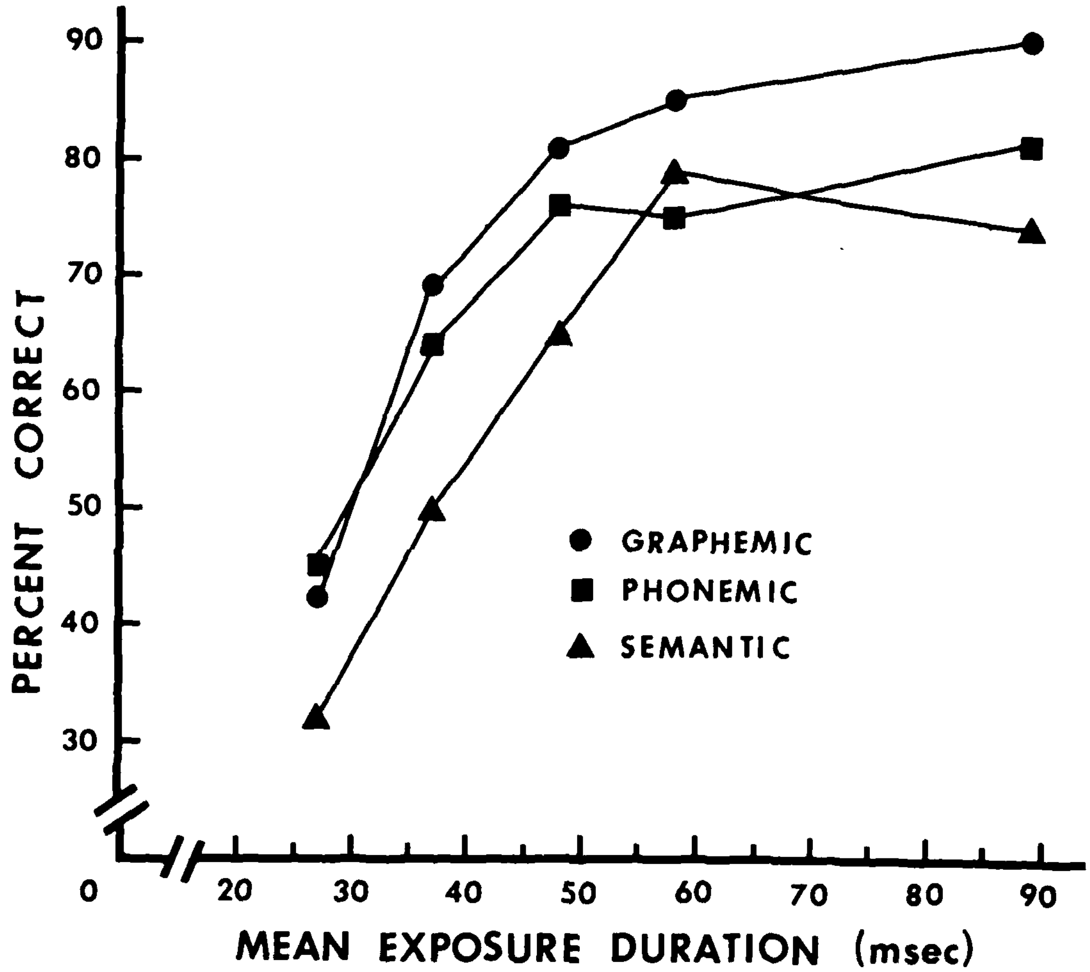

Figure 2. Mean numbers of correct responses to the three types of questions (replication).

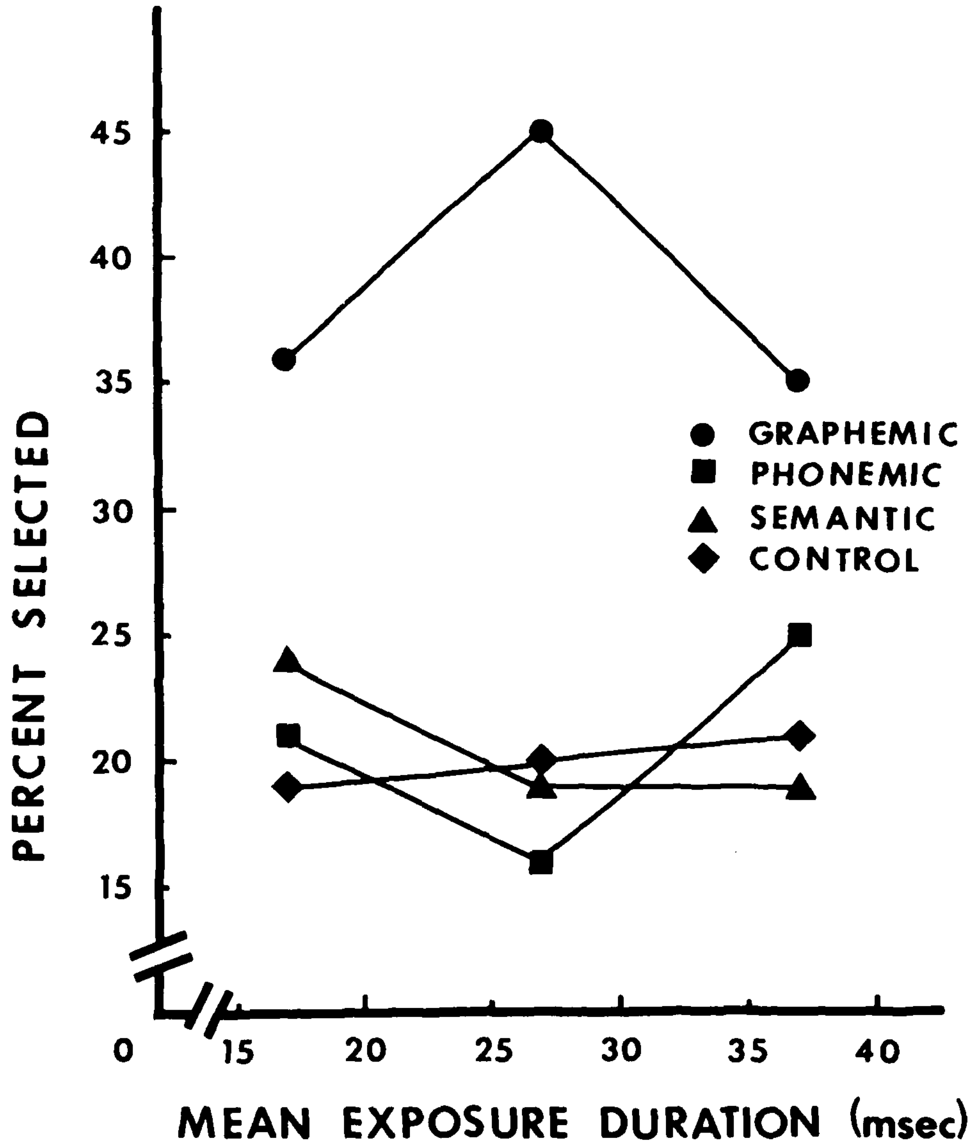

Figure 3. Mean percentages of the four alternatives selected at various exposure durations.

adequate probability of clear separation between the longer intervals. Despite this limitation, the utility in brief stimulation techniques of the commonly occurring raster-scan CRT was suggested by the finding of a linear relationship between the nominal time intervals and real time stimulus presentations.

A second aspect of our methodological investigation of the raster-scan CRT involved manipulation of the energy variable as a means of degrading the stimulus. Such degradation was intended to enlarge the critical timing area over which subliminality could be manipulated.

Following this extensive investigation of stimulus degradation, we performed additional research on the same basic question using a new design. The new procedure provided both a pretest and posttest threshold determination session, rather than the exposure of all of the subjects to the same range of SOAs. By manipulating both the energy level of the stimulus and the SOA we selected an appropriate set of conditions for each subject at which the tests could be run. Also, half of the targets were blanks, so that a comparison of target-present (experimental) and target-absent (control) scores could be made for each test condition, thus controlling for differences among foils and information that might be gained from the test alternatives themselves apart from the target.

Method and Results

A total of 28 subjects were run in this phase. The first 14 were tested under relatively stringent conditions. That is, their threshold was determined on the basis of their having correctly selected less than 25% of the target words shown at some particular energy and time values. This level was chosen to ensure that their selection was below the chance baseline (1 of the 4 alternatives).

Although a trend in the predicted direction was found, with somewhat higher selection levels for presented targets than for blanks, no statistically reliable differences were obtained.

This stringent threshold criterion may well have resulted in very little information processing, because the 25% level could be, in effect, anywhere from zero to 25%. A second set of 14 subjects was therefore run under somewhat liberalized conditions. The criterion was set at 40%. That this level was effective in eliminating conscious recognition of the targets is indicated by the fact that on only two occasions, out of a total of 624 opportunities (.3%, figured for the 13 subjects whose threshold determinations were found to be adequate, by a posttest) were these subjects able correctly to identify the target word presented. As a matter of fact, 7 of these subjects made no identification efforts whatsoever. In any event, the correlation between number of at least partially successful identifications (2 or more letters correctly identified) and correct selections in the recognition test was quite negligible (-.02). It seems clear that, as judged by identification performance, the targets were essentially "subliminal".

The analysis of the recognition test data from the 13 subjects who provided acceptable data is, at this writing, incomplete. Most of the present analysis is concerned with rather refined questions, such as the role of a certain number of duplications of target words and alternatives, and a word-frequency analysis of the test sets. Nevertheless, a good number of basic analyses are completed and it does seem that the major results of the first experiments have been confirmed. Overall, for example, there was a statistically reliable superiority of correct scores following a target compared with a nontarget presentation, $F(1, 12) = 9.54$, $p < .05$. Specific comparisons (paired t-tests) were also made independently for the three types of test alternatives. Those data are shown in Figure 4. Only the graphemic comparison yielded a reliable effect ($t = 2.33$, $p < .03$). This latter result confirms the general superiority of graphemic performance that was indicated in the early experiments. Certainly there was no support for Marcel's (1978) report that semantic processing is prior to graphemic at very brief SOAs.

Discussion

On the basis of the completed experiments it does appear that we have replicated Marcel's (1978) finding of superior performance of at least graphemic test items following subliminal presentation of targets. If the failure of our subjects to make any appreciable identification of the targets is accepted as evidence of subliminal stimulation, then the evidence for the effectiveness of information processing seems to be reasonably firm.

Beyond this support of the reality of such unconscious processing, there are two major implications of these results. First, it does appear that our initial intention, to test the hypothesis of differential subliminal processing of rewarded responses, can be implemented under the experimental conditions used. Such tests are now underway.

Second, there are some implications for more applied research that can be drawn from these experiments. If such subliminal processing of information does occur to a significant degree, it may well be that there are perceptual-motor skills which can be improved by appropriate subliminal training. Are there any such skills in military operations? One that would seem to be a prime candidate for experimental testing is the ability to make perceptual judgments on the basis of very slight stimulus input. Identification of, say, aircraft under highly degraded visual conditions or detection of hidden targets are examples of such skill.

This kind of perceptual skill, of undoubted importance in many Army operations in the field, is clearly dependent upon the effectiveness with which an observer can utilize ("process") minimal sensory information, such as very slight movements in the case of the hidden target. Certainly a substantial proportion of such cues are at or below threshold. Thus, one might well expect that training in subliminal information processing can improve the efficiency with which such processing is utilized in tasks like detection of hidden targets, and experimental testing of this hypothesis is indicated.

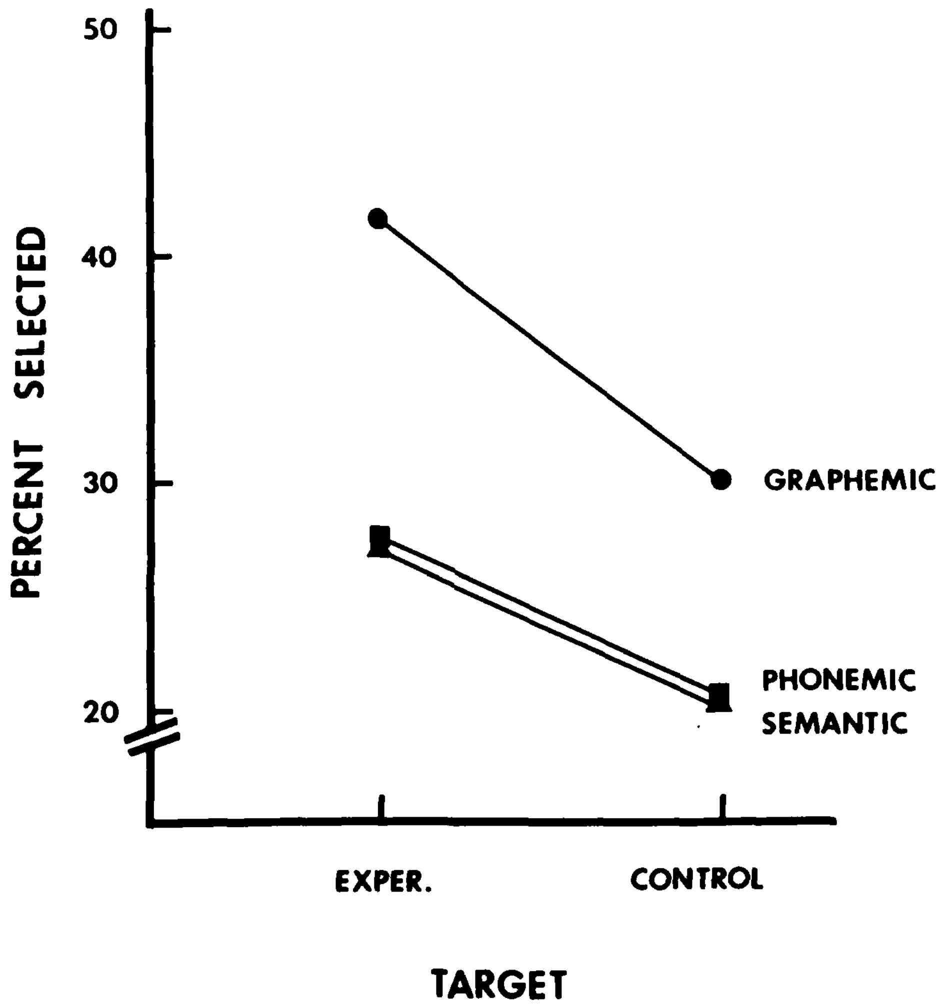

Figure 4. Mean percentages of the graphemic, phonemic, and semantic associates selected as a function of presentation of the target word (exper.) or a blank (control).

II. NONCOGNITIVE DETERMINANTS OF RESPONSE STRENGTH

A number of experiments on the basic problem of reinforcement, not involving subliminal processing, were also completed under the grant. Most of these have been published so here they will be briefly described.

Reinforcement Problem: Perform/Observe, Transfer and Gender Variables

Several studies using high school subjects bore directly on this problem. The major results will be summarized. Marx (1979a) found that transfer in observing subjects was inhibited by requiring these subjects to score the performance of their paired performers, but only in males. An initial but temporary inhibition in transfer associated with observer scoring was also found in a later experiment (Marx, Homer, and Marx, 1980). Marx (1979b) found that transfer was relatively superior after observation in females, but no difference between observation and performance was found in males. Marx (1979c) found suggestive evidence that transfer is more effective after observation for more difficult materials. In a somewhat tangential approach to the reinforcement transfer problem Kim, Broyles, and Marx (1981) manipulated transfer conditions by means of shifting task difficulty. They found positive transfer for the hard-easy shift and a tendency for negative transfer from the easy-hard shift.

In another series of experiments on this problem superior acquisition was found for performers, and for females (Marx, Homer, and Marx, 1980). In this experiment observer scoring was found to be very inhibitory for conceptual (C) but not for rote (R) materials, as shown in Figure 5. Another experiment (Marx, Marx, and Homer, 1980) found superior acquisition and retention after performance, compared with observation, and also that performers were relatively better on rote (R) learning materials (see Figure 6). The latter result is consistent with data earlier obtained (Marx, 1979c) and with the interpretation that provides a greater role for direct strengthening of responses by reward when less "cognitive" processes are involved.

A final experiment in this series (Marx, Marx, and Homer, 1981) varied the level of organization of the stimulus materials in a verbal learning discrimination task. Again there was a higher level of correct performance for the performers compared with subjects who had been informed of the same answers (equivalent cognition therefore again assumed). Incidental recall of more performed than informed errors again occurred (as in Marx, Homer, and Marx, 1980) for the male subjects, confirming the earlier result showing a greater tendency for males to repeat both correct and incorrect responses (Marx, Witter, and Farbry, 1973). However, there was no interaction between the performance variable and the level of organization of the materials, as there had been in the earlier (Marx, Marx, and Homer, 1980) study, suggesting that this less clearcut manipulation of organization (level of organization, rather than number of conceptual categories, varied in the previous experiment) is a less effective manipulation.

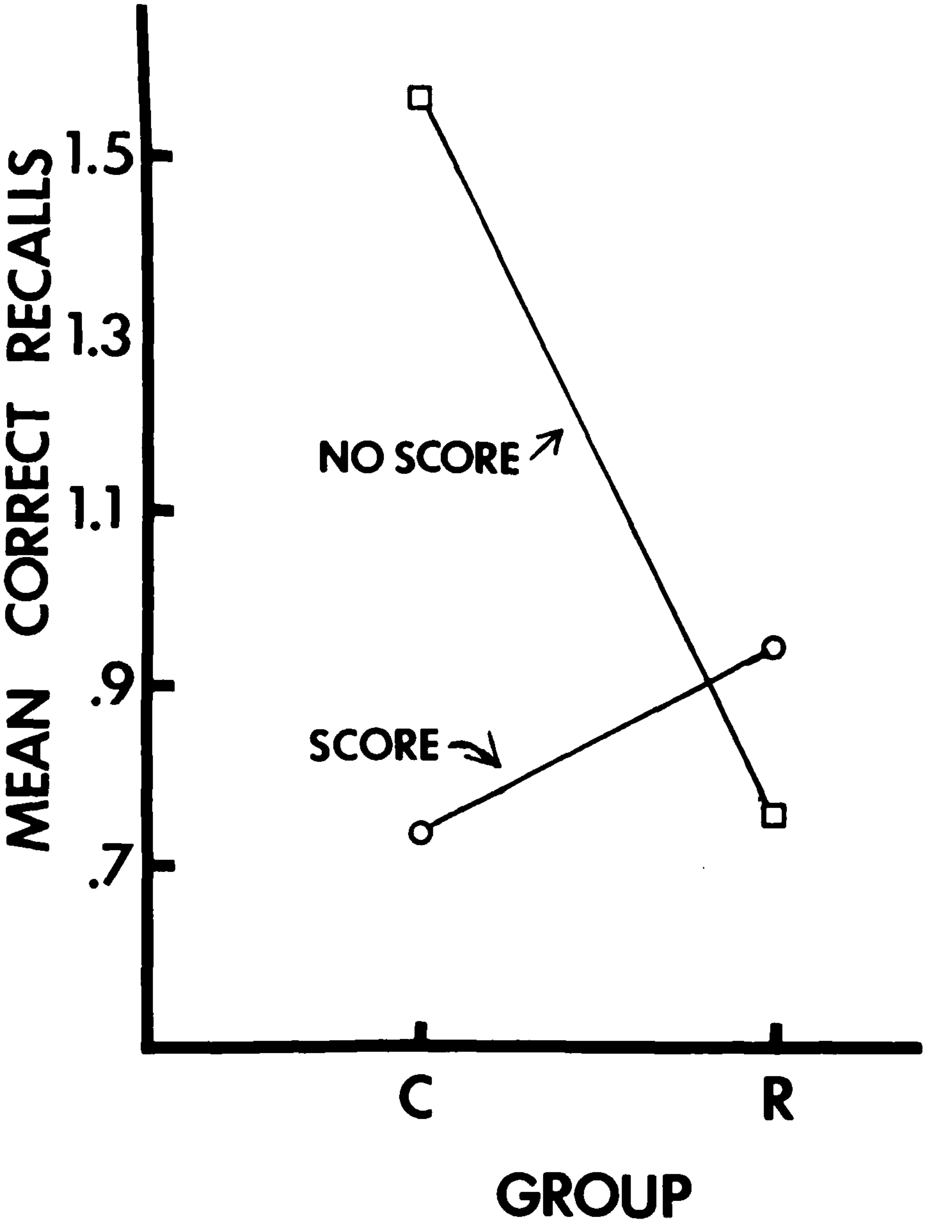

Figure 5. Mean number of correct words recalled in immediate retention as a function of group and scoring variables.

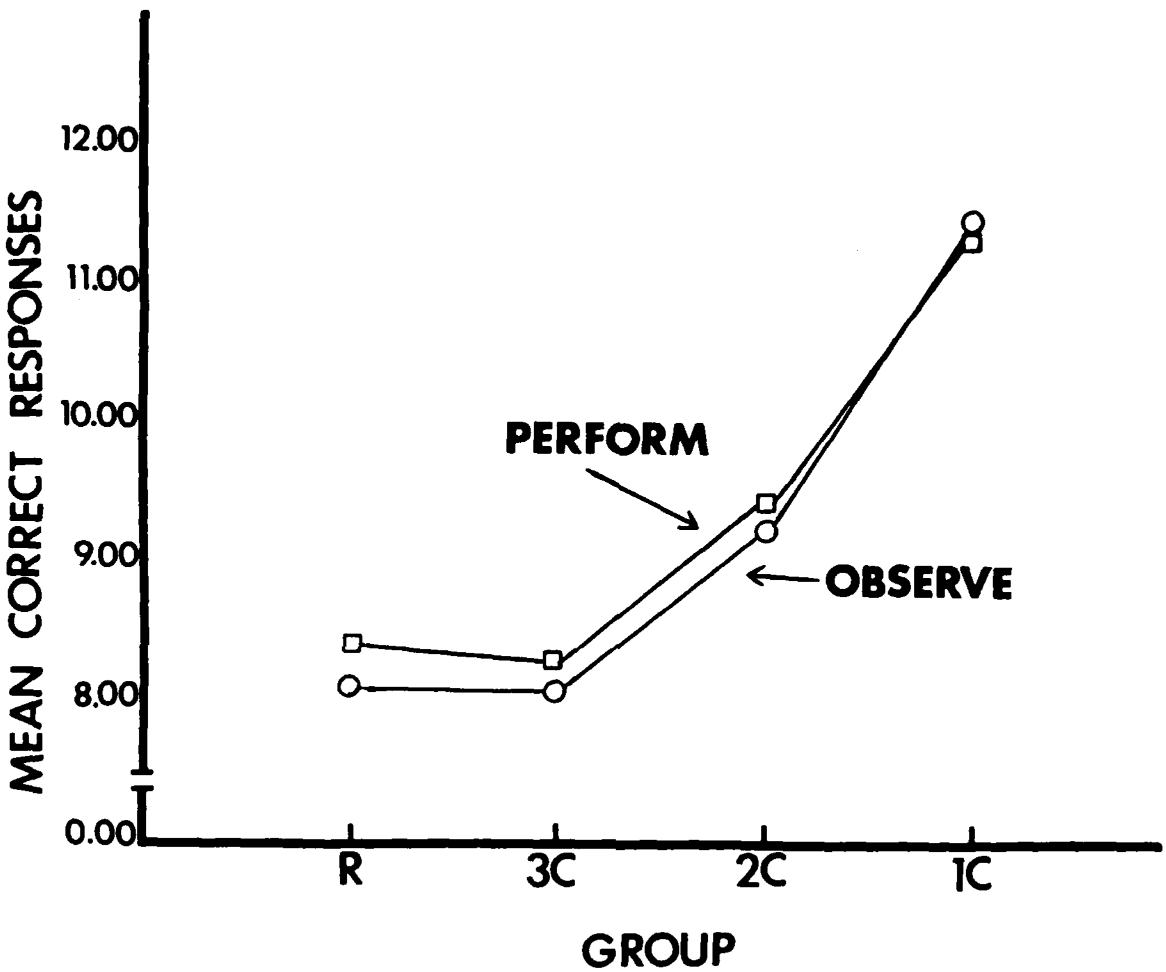

Figure 6. Mean number of correct responses in acquisition under performance and observation as a function of the task variable.

The consistent finding, in the experiments just described, of greater acquisition of performed than informed words suggests that this kind of learning condition at least is more favorable for the kind of condition under which some sort of direct strengthening of responses from reward may be expected to occur.

Error Strength

Two types of experimental attack have been made on the problem of strengthening of errors. In the first approach (Marx and Marx, 1980b) we found a relatively greater amount of learning and retention of erroneous responses that had been given earlier as associates to the same cues by the same subjects, suggesting that prior response (associative) strength plays a role in human learning and memory, although such a role plays little or no part in most "cognitive" theories.

The other approach investigated what we have called the "Stubborn Error Effect" (SEE). This refers to the general tendency for certain errors to increase in strength, rather than be eliminated, the more often they occur. Marx and Marx (1980a) confirmed the SEE, especially for males (13 of 42 males showing the effect, compared with only 8 of 70 females). The generality of the SEE may be questioned on the basis of these data, because only 21 of the 113 subjects showed it. In a later report (Kim, Marx, and Broyles, 1981) the SEE as a group phenomenon was again confirmed, especially for the less capable subjects and for the shorter (1 sec) rather than the longer (2 sec) stimulus presentation, but no gender difference emerged.

Anagram Solution

Anagram solution was investigated as a function of the frequency of occurrence of target words in an immediately preceding, and presumably unrelated, word-completion task (Marx, 1982). Word recall in that task was found to be a negatively accelerated function of the frequency of occurrence. Anagram solution, however, was found to be inversely related to recall (recalled words were reliably less likely to be solved) and also, although not reliably, to the frequency of recurrence of target words in the prior task. These results are shown in Figure 7. They are interpreted as suggesting that cognition, at least under some circumstances and as measured by recall, may be inversely related to transfer and, more generally, that cognitive factors need to be supplemented by noncognitive factors in the interpretation of learning and transfer.

General Discussion

Two major conclusions may be drawn from this research on the reinforcement problem. First, with respect to the underlying theoretical issue, the cumulative impact of the studies does seem to justify the conclusion that the presumed noncognitive determinants of "reinforcement" merit continued experimental attention (Marx, 1981).

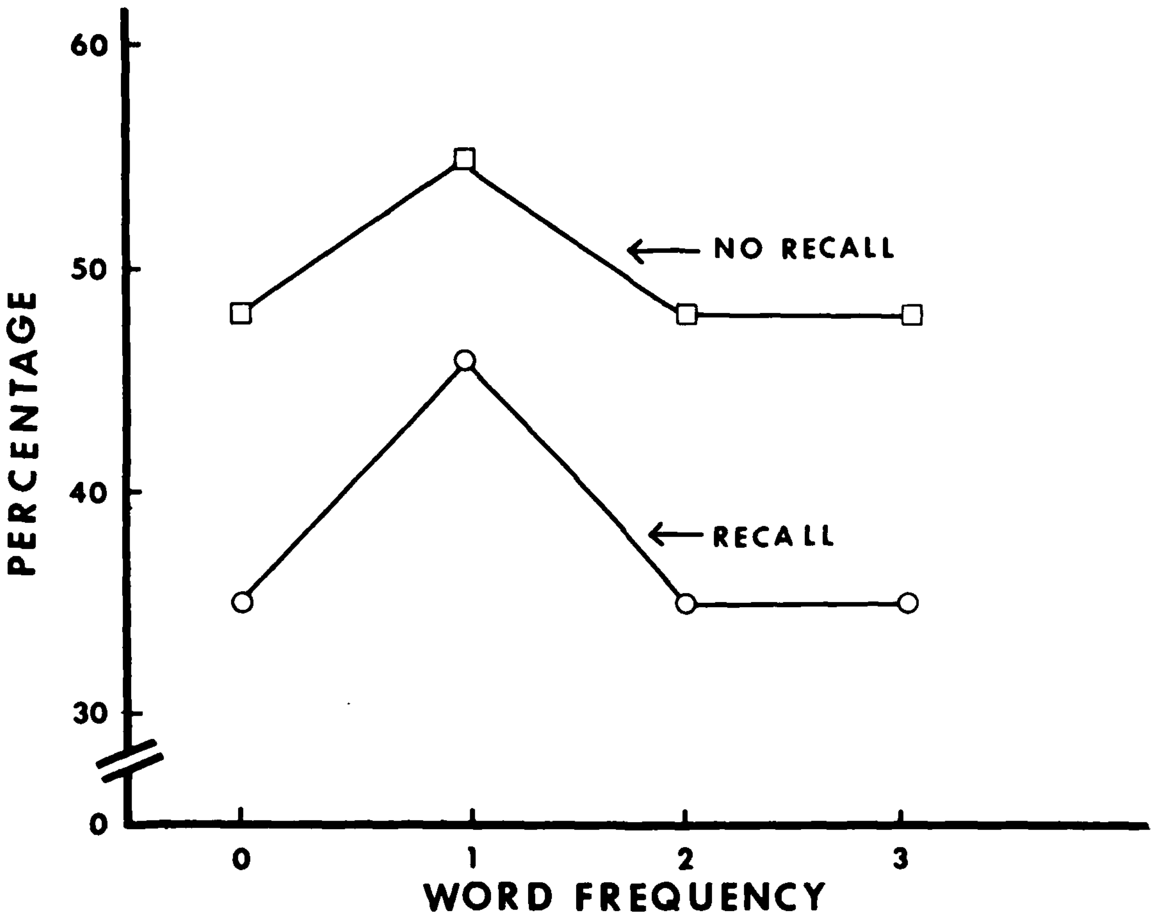

Figure 7. Percentage of successful retrieval of target words in anagram solution as a function of word frequency and of prior recall or no recall of target words.

Second, from an applied perspective, some of the results would seem to have a number of interesting implications for training. For example, the surprisingly generalized inhibitory effect of scoring suggests that attention be paid to this variable in training regimes where correction of errors is required. For another example, the pervasive occurrence in these experiments of gender differences raises some obvious questions. Thus, females have been shown not only to be more resistive to *the scoring-inhibition effect* but also, somewhat more suggestively, to be less likely to make stubborn (extremely persistent) errors. On the other side of the coin, male high school students have been shown to be more subject to distractions (like the scoring task) as well as more likely to repeat their own responses, incorrect as well as correct.

Although these and other implications of our studies are far from conclusive, they do point to a host of empirical manipulations that can be tried out in training situations. Moreover, they emphasize the failures in learning as well as the successes, in a way that the typical cognitive theory is unlikely to do. Clearly, the human subject is a superbly equipped cognitive learning agent. In addition to asking what such a subject <u>can</u> do, however, we need to look more carefully at what the subject <u>does</u> -- at errors, that is, as well as correct responses. In other words, what accounts for the failures to perform properly in accordance with the cognitive structures that have been established? Obviously, there are many conditions that contribute to errors. It is interesting that these conditions are more likely to obtain in real-life training and performance than they are in the typical laboratory test, especially when adequately motivated and intellectually capable college students are the subjects.

Conclusions

This technical report has summarized two major lines of research bearing on an analysis of the reinforcement process. Both the preliminary manipulation of unconscious information processing and the more developed experimentation in the other studies point to limitations in the typical cognitive view of learning and performance. They are important because they document the need for taking a larger view, including noncognitive as well as cognitive determinants. And this larger perspective is especially important when one is concerned with the less-than-perfect performances of real-life learners and operators, in military and other work settings.

FIGURE TITLES

Figure 1. Mean numbers of correct responses to the three types of questions

Figure 2. Mean numbers of correct responses to the three types of questions (replication)

Figure 3. Mean percentages of the four alternatives selected at various exposure durations

Figure 4. Mean percentages of the graphemic, phonemic, and semantic associates selected as a function of presentation of the target word (exper.) or a blank (control)

Figure 5. Mean number of correct words recalled in immediate retention as a function of group and scoring variables

Figure 6. Mean number of correct responses in acquisition under performance and observation as a function of the task variable

Figure 7. Percentage of successful retrieval of target words in anagram solution as a function of word frequency and of prior recall or no recall of target words

References

Broyles, J. W., Prill, K. A., Marx, M. H., Salthouse, T. A., & Spencer, K. L. An empirical approach to the timing limitations of the raster-scan CRT. Bulletin of the Psychonomic Society (in press).

Dixon, N. F. Preconscious Processing. Chichester, England: John Wiley & Sons, 1982.

Eriksen, C. W. Discrimination and learning without awareness: A methodological survey and evaluation. Psychological Review, 1960, 67, 279-300.

Fowler, C. A., Wolford, G., Slade, R., & Tassinary, L. Lexical access with and without awareness. Journal of Experimental Psychology: General, 1981, 110, 341-362.

Kim, Y. C., Broyles, J. W., & Marx, M. H. Transfer as a function of shifts in task difficulty in verbal discrimination learning. Bulletin of the Psychonomic Society, 1981, 18, 142-144.

Kim, Y. C., Marx, M. H., & Broyles, J. W. The stubborn error effect in verbal discrimination learning. Bulletin of the Psychonomic Society, 1981, 18, 5-8.

Marcel, T. Unconscious reading. Visible Language, 1978, 12, 391-404.

Marcel, T. Conscious and preconscious recognition of polysemous words. In R. S. Nickerson (Ed.), Attention and Performance VIII, Hillsdale, N. J.: Lawrence Erlbaum Associates, 1980.

Marx, M. H. Multiple-choice learning of line-drawn facial features: I. Inhibitory effects of observer scoring. Bulletin of the Psychonomic Society, 1979, 14, 437-438.

Marx, M. H. Multiple-choice learning of line-drawn facial features: II. Sex differences. Bulletin of the Psychonomic Society, 1979, 14, 439-441.

Marx, M. H. Multiple-choice learning of line-drawn facial features: III. Transfer as a function of performance or observation. Bulletin of the Psychonomic Society, 1980, 15, 57-59.

Marx, M. H. Habit activation in human learning. In G. d'Ydewalle & W. Lens (Eds.), Cognition in Human Motivation and Learning, Hillsdale, N. J.: Lawrence Erlbaum Associates, 1981, pp. 87-122.

Marx, M. H. Effects of frequency of prior incidental occurrence and recall of target words on anagram solution. Bulletin of the Psychonomic Society, 1982, 19, 253-255.

Marx, M. H., Homer, A. L., & Marx, K. Verbal discrimination learning and retention as a function of task and performance or observation. Bulletin of the Psychonomic Society, 1980, 15, 167-170.

Marx, M. H. & Marx, K. Repetition of errors in learning and memory as a function of their prior associative strength. Bulletin of the Psychonomic Society, 1980a, 16, 435-438.

Marx, M. H., & Marx, K. Confirmation of the stubborn-error effect in human multiple-choice verbal learning. Bulletin of the Psychonomic Society, 1980b, 16, 477-479.

Marx, M. H., Marx, K., & Homer A. L. Verbal discrimination learning and retention as a function of performance or observation and ease of conceptualization of task materials. Bulletin of the Psychonomic Society, 1980, 16, 135-136.

Marx, M. H., Marx, K., & Homer, A. L. Interactions among performance, task, and gender variables in verbal discrimination learning. Bulletin of the Psychonomic Society, 1981, 18, 9-11.

Merikle, P. M. Unconscious perception revisited. Perception and Psychophysics, 1982, 31, 298-301.

Nolan, K. A., & Caramazza, A. Unconscious perception of meaning: A failure to replicate. Bulletin of the Psychonomic Society, 1982, 20, 23-26.

Wickens, D. D. Encoding categories of words: An empirical approach to meaning. Psychological Review, 1970, 77, 1-15.